SOPHIE:
INTERNATIONALLY COLLABORATE ON COST-EFFECTIVE SHP-PROPERTIES USE, DETERMINATION, AND DISTRIBUTION

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Why Motivation and problem statement

SOPHIE stands for SOil Program on Hydro-physics via International Engagement. Soil Hydro-Physics (SHP) properties are THE properties that determine the Soil-Water-interactions:

- water flow and water retention
- and with the water flow the transport of dissolved compounds, like nitrogen, phosphates, pesticides, antibiotics, organics, etc.

As a result SHP-properties play an important role in variety of societal issues: Crop water stress vs. food security, Salinity and Sodicity occurrence, Susceptibility for forest fires, Soil compaction, Dike stability, Greenhouse gas emissions, Soil health, etc.

The need for reliable SHP-properties is widely emphasized by researchers and consultants. However, concurrently it is recognized that harmonization, and the development of new techniques is difficult to accomplish. This is due to the missing attention and missing direct visibility of SHP-properties in the societal topics they address. As a result current methods are still time consuming, and thus not cost-effective, and are not sufficiently harmonized to be used on EU-scale research.

Still, there are opportunities to improve the situation drastically, but these methods require large scale adaptation, validation and standardization. Just one example is the adaptation, and innovation towards novel remote and proximal sensing techniques. When they are used in combination with modern field and laboratory techniques, they can lead to standardized SHP-properties, directly usable for extending current soil data bases, like LUCAS, and in large scale studies.

What Approach, results and key messages

To accomplish this, SOPHIE works on the development of an international network that is needed and will be used as a driving force to Harmonize, Standardize and Innovate towards cost-effective measurements of Soil Hydro-Physics (SHP) Properties. It has the ambition to provide a generally accepted degree of standardization of SPH property determination in field and laboratory, and to provide SHP data that is based on standardized procedures to be used as a support for the EU Soil Policies.

Key Conclusion and take home message

The workshop during the INSPIRE meetings in Brussels is used to build upon commitment among policy makers, manufacturers, developers, researchers, and users.

As the above described situation was underlined almost unanimously during the workshop, and representatives of the International Soil Modeling Consortium (ISMC), the International Soil Reference and Information Centre (ISRIC), and the other participants indicated their commitment towards developing SOPHIE, is was concluded that this initiative should be extended. In future events, prominent contributions from partners and EU policy makers, contributing to the strategic research agenda and program wise development, will be encouraged and highly appreciated.

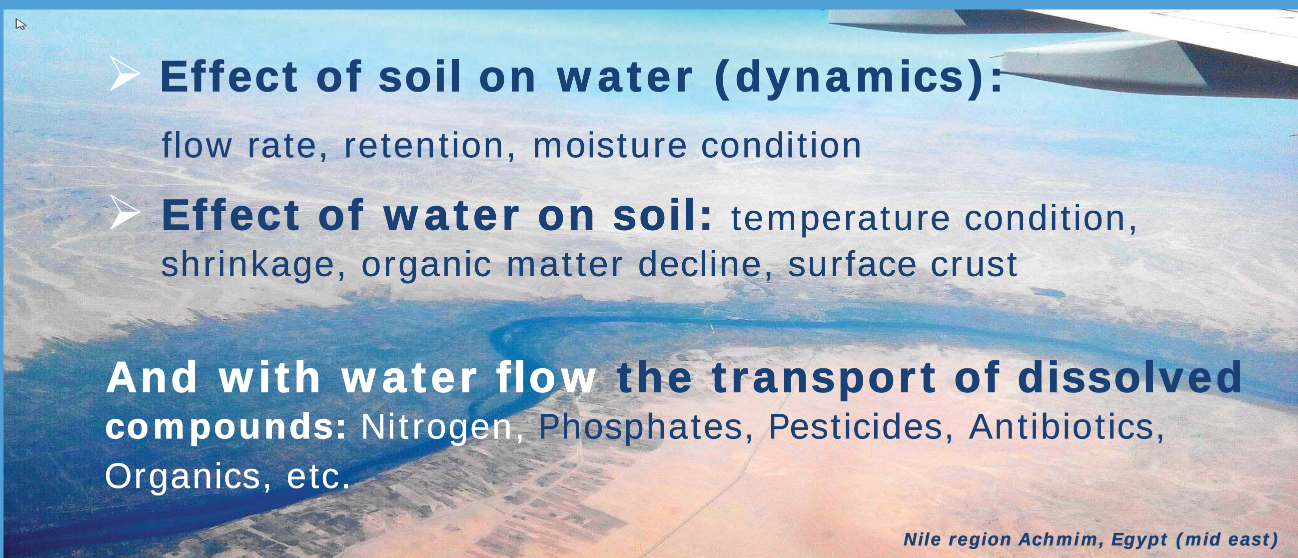
SOPHIE

December 2017

Gerben Bakker & Martine van der Ploeg

SOPHIE = SOil Program on Hydro-physics, via International Engagement

Hydro-physics properties are THE properties that determine the soil-water-interactions:



- **Effect of soil on water (dynamics):** flow rate, retention, moisture condition
- **Effect of water on soil:** temperature condition, shrinkage, organic matter decline, surface crust

And with water flow the transport of dissolved compounds: Nitrogen, Phosphates, Pesticides, Antibiotics, Organics, etc.

Nile region Achmim, Egypt (mid east)

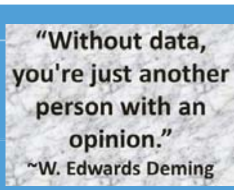
SHP properties essential in variety of societal issues
➔Outcomes strongly depend on Soil-Water-condition

Soil Hydro-Physics (SHP) 3 Main pillars	Soil-Water-Interaction directly affects
Water flow rate **Water Retention** **Moisture content**	• Crop water stress vs. food security • Salinity and Sodicity occurrence • Flow of Nutrients, Contaminants, Antibiotics • Waterlogging / ponding • Soil fauna and Nature development • Forest fires • Drainage design • Drinking water availability • Greenhouse gas (N_2O/CO_2) emissions • Compaction • Erosion • Weather / Climate • Dike stability • Soil shrinkage/cracks vs building/road damage

Challenges for SHP-properties (SHPs)

- Need for reliable SHPs are often not well recognized and underestimated
- Still expensive, needs harmonisation, standardization, and modernization
- Use of old data → inaccurate results
- As being basic data, SHPs are invisible in EU formulated societal issues, proposals and outcomes
- There is no integral program-wise development towards efficient SHPs collection

SOPHIE Ambition



Internationally collaborate on modernizing SHP-properties use, determination, and distribution

by

- **Harmonisation** (method and threshold comparison)

  International use of same golden, silver and bronze standards; inter-comparison via standard samples; use of comparable threshold values

- **Standardisation** (used methods: golden, silver, bronze)

  What parameters are crucial; How must they be determined; How must they be stored in dBase; standardize to general acceptable level

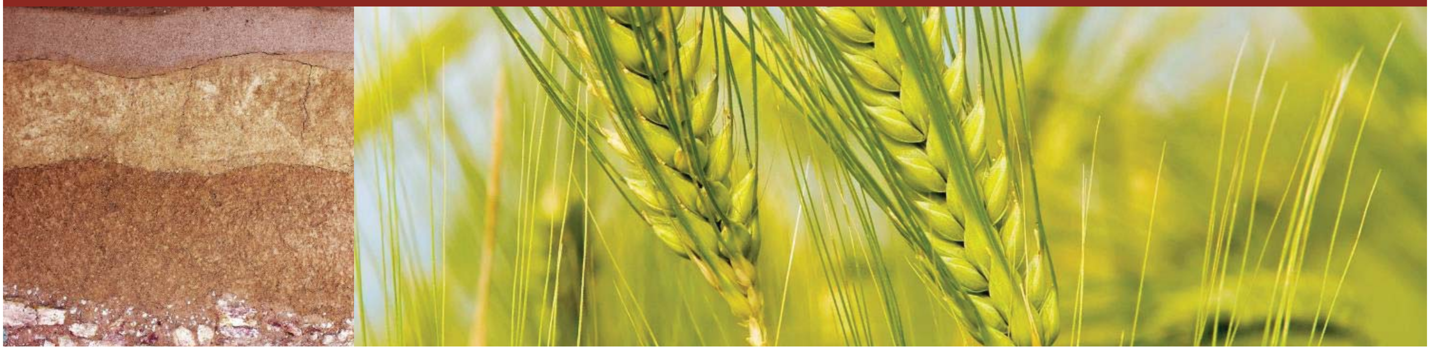
- **Innovation** (efficient equipment, models, dBases)

  Stimulate modernization into efficient field-, and laboratory equipment and model development, e.g. combine proximal sensing (PS), remote sensing (RS), field and lab techniques to increase output and reduce costs.

Thank you

Standardization and harmonisation for global soil data provision

Rik van den Bosch, Director



Contents

- About ISRIC – World Soil Information
- Our experience in soil information systems
- Standardisation at ISRIC
- About GSP Soil Data Facility

ISRIC – World Soil Information

ISRIC World Soil Information

Some features

- Founded in 1966, upon recommendation of UNESCO, FAO and the IUSS
- Independent foundation based in Wageningen
- Cooperation agreement with Wageningen University.
- 20 staff, plus guest employees, plus students
- Accredited as the World Data Centre for Soils (WDC – Soils) by the International Council for Science
- Participating Organisation of the Intergovernmental Group on Earth Observations (GEO)

ISRIC World Soil Information

Vision

A world where **reliable** and **relevant** soil information is **freely-available** and **properly used** to address **global** environmental and social **challenges**.

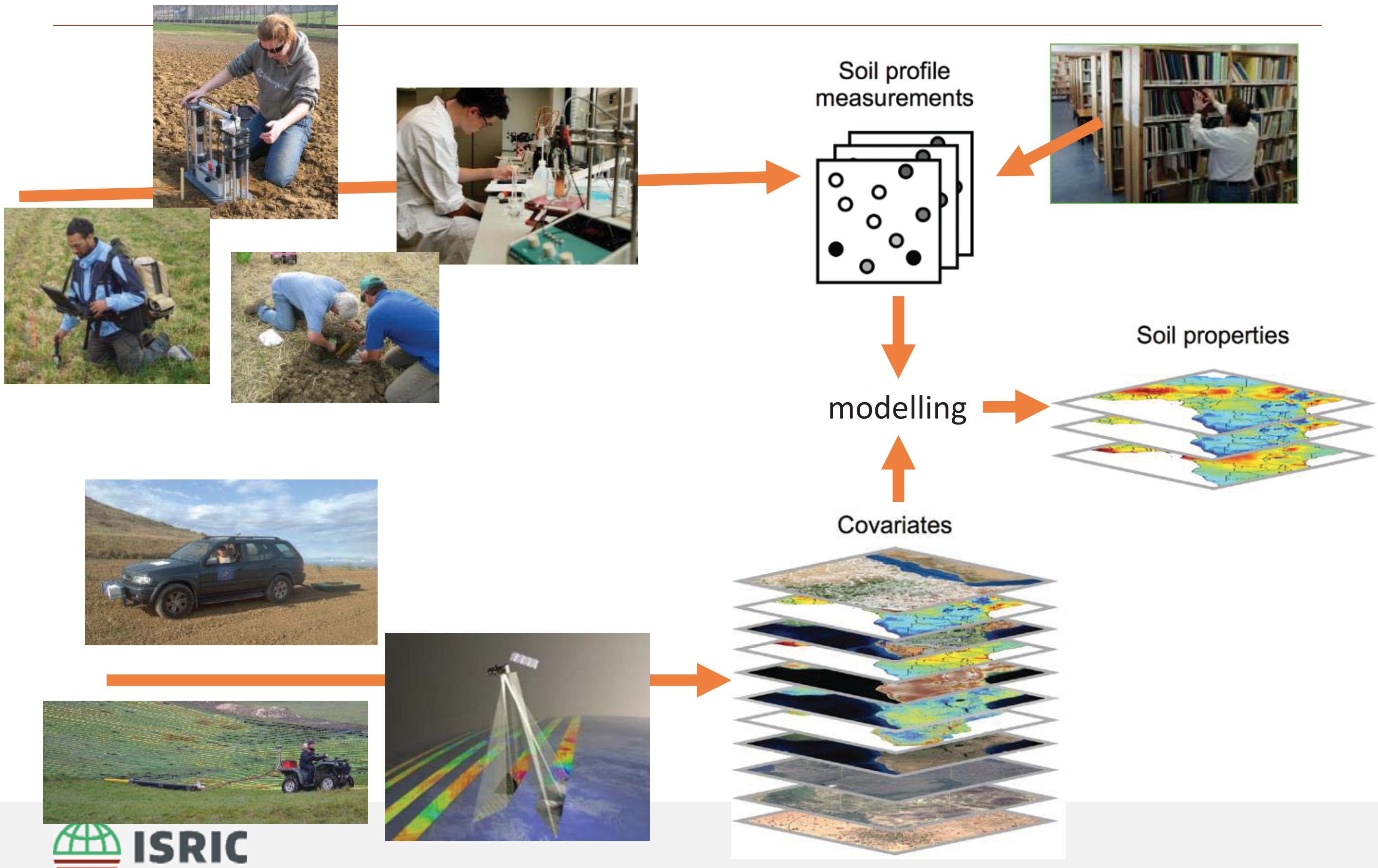
Mission

- We produce and serve **quality-assured soil information** together with our partners at global, national and regional levels.
- We stimulate the use of this information to address global challenges through **capacity building**, **awareness raising** and direct **cooperation** with users and clients.

Vision on our role

- We are a **service provider** to the international science communities, policy communities and the private sector
- ISRIC plays a significant role in **standard setting** for soil data gathering storage and serving ('Foundation')
- ISRIC is the **trusted broker** of global soil information for different client groups connecting global producers and users of soil information (Raison d'etre')
- ISRIC **develops capacity** for building and using soil information systems in developing countries ('connecting with the market')
- ISRIC develops **derived knowledge products** for sustainable soil and land management, together with clients and partners ('increasing impact')

From measurements to information



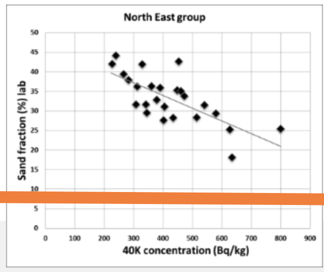
ISRIC
World Soil Information

Data acquisition process

- New point data (eg. AfSIS, LUCAS, project data etc.), lab or sensor based.

- New spatial information:
  - Estimation of properties through sensing
  - Covariates (eg. DEM, Land use satellite data etc.)

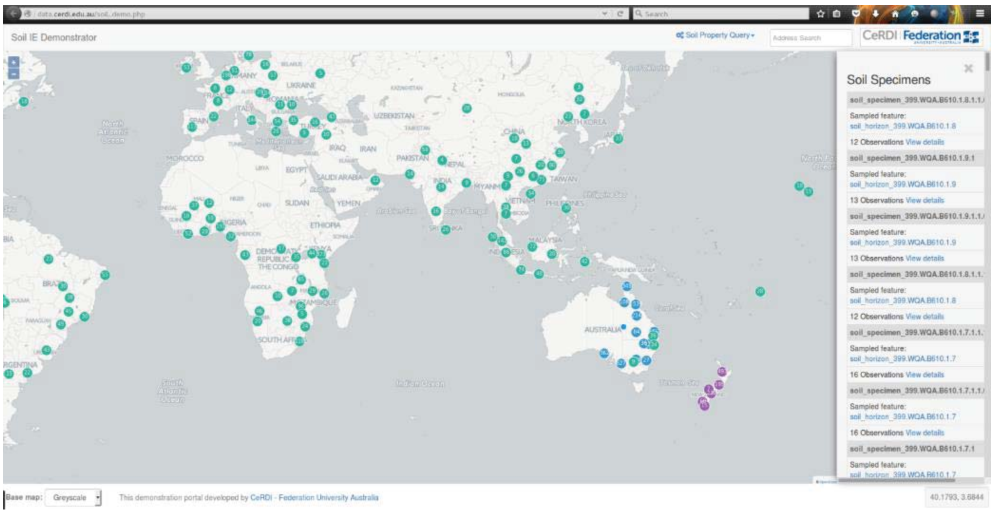
- Existing data and data collected for other projects



Work stream 1: Reference and Standard Setting ('The Foundation')

World Reference Base (WRB)

Soil Data Interoperability Experiment



Manaaki Whenua Landcare Research

CSIRO

Federation University Australia

OGC® Making location count.

ISRIC World Soil Information

GODAN Working Group on Soil Data

Initiatives:

IUSS WG - SIS

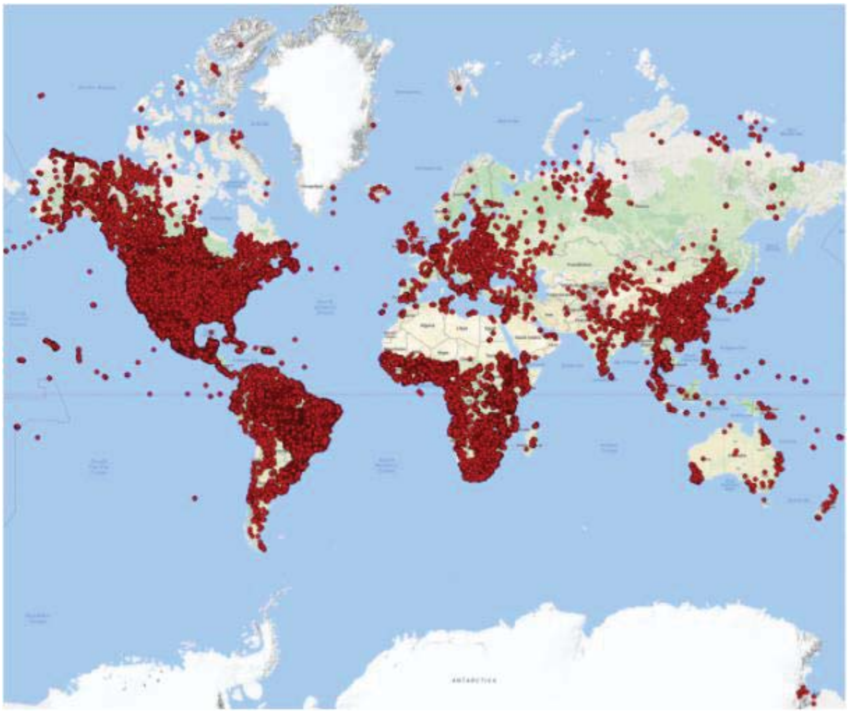
Partners:

50 subscribers
38 organisations
7 international presentations in 2017

Your organisation?

Work stream 2:
Soil Information Brokering
(‘Raison d’être’)

Data holdings in WoSIS (June 2017)



- ~ **126 thousand** unique profiles
- ~ **111 thousand** profiles with geometry
- ~ **30 million** soil properties measurements of which
  - ~ **4 million** have been standardized so far
- Bulk density
- Calcium carbonate
- Carbon (Total & Organic)
- Coarse fragments
- pH
- Water retention
- Texture (Sand, Silt, Clay)
- Cation exchange capacity
- Electrical conductivity
- Classification: FAO, WRB, US Soil Taxonomy

WoSIS: World Soil Information Service

- PostgreSQL database developed to:
  - Store soil data with their lineage (e.g. licence)
  - Standardize and harmonize the disparate source data
  - Ultimately serve quality-assessed soil data for a range of applications
- Provides the basis for a distributed system

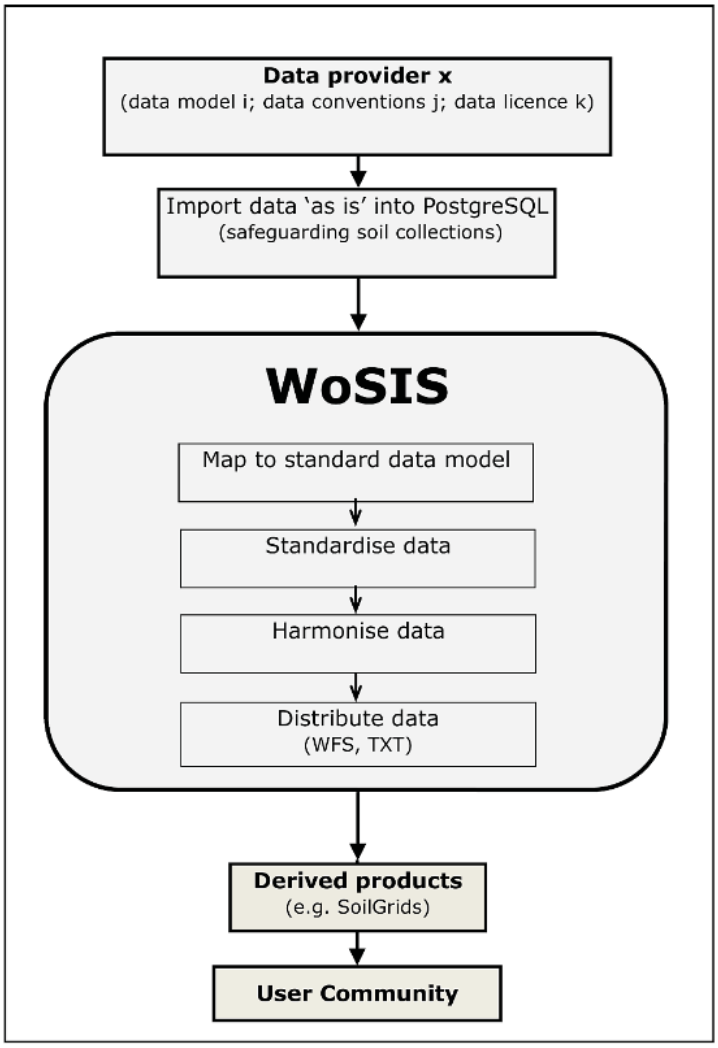
"Decision makers and managers must have access to the information they need, when they need it, and in a format they can use"
(GEO, 2010)

See: ISRIC Data and Software Policy

Main steps in data processing

And:

- Consistency checks & quality control scheme
- Managing intellectual property rights: respecting the IP of data owners/contributors



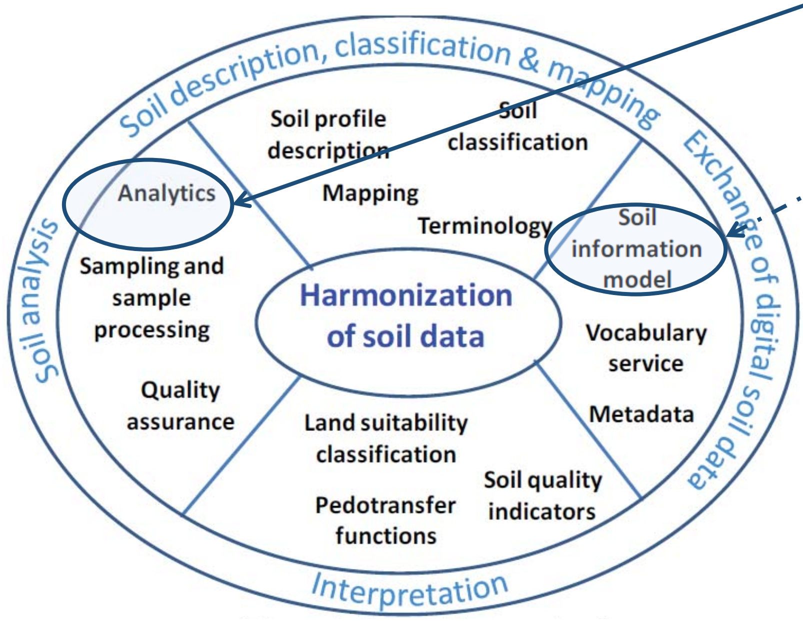
Standardisation steps

- Identify repeated profiles
- Attribute names
- Units (incl. conversion factors)
- Formats of measured values
- Analytical methods

➢ Current focus: soil properties considered in GlobalSoilMap specs

pH
Organic carbon
CEC
Bulk Density
Water Holding Capacity [b]
Calcium carbonate equivalent
Sand, silt, clay fractions
Coarse fragments (>2mm; as volume percent of whole soil)
Electrical conductivity

Areas of harmonization



Present focus in WoSIS
(soil data derived from routine soil surveys)

GLOBAL SOIL PARTNERSHIP

"Providing mechanisms for the collation, analysis and exchange of consistent and comparable global soil data and information"
(GSP Pillar V)

Harmonize to reference method 'Y'
(not yet undertaken in WoSIS)

- Make the data comparable, as if assessed by a single given (reference) method Y
- There is generally no universal equation for converting from one method to another in all situations
- GSP community will need to develop 'region' specific conversions building on comparative analyses of (archived or new) soil samples (GSP WG5, Baritz et al. (2014); GLOSOLAN)

Source: GlobalSoilMap (2013)

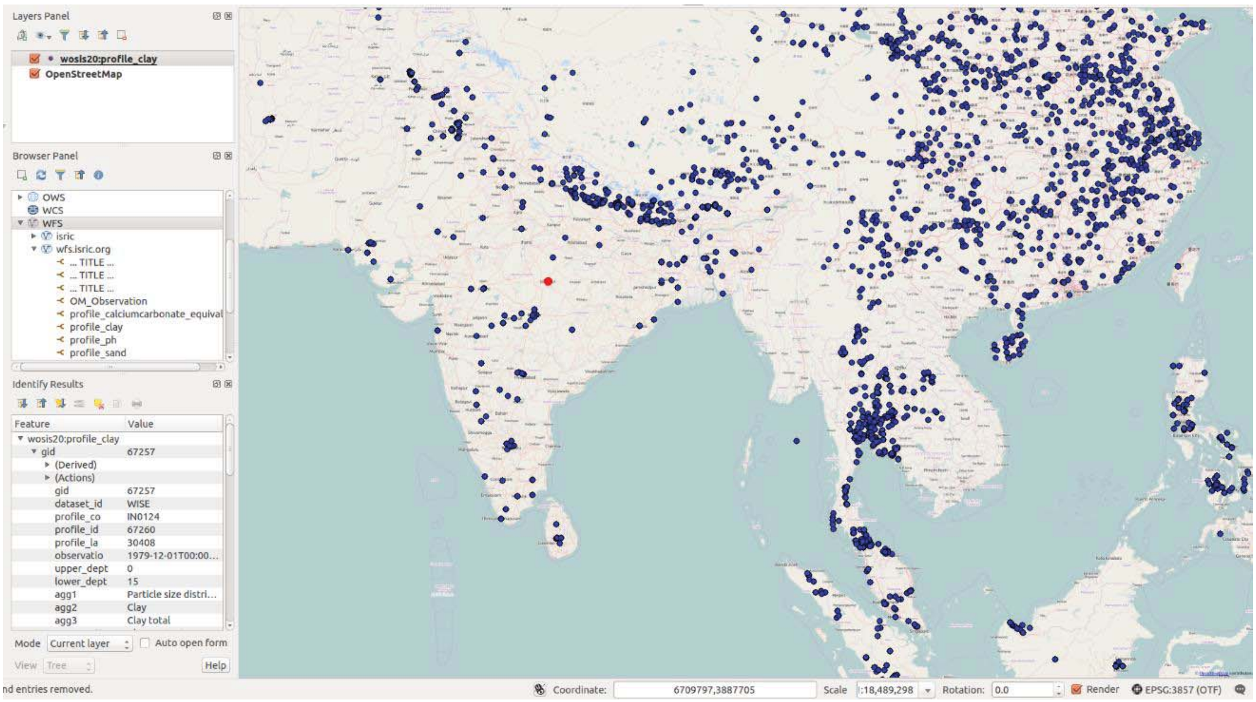
Harmonize to reference method ‘Y’
(*not yet undertaken in WoSIS*)

Table 11 Example regression equations for converting values of pH between different methods

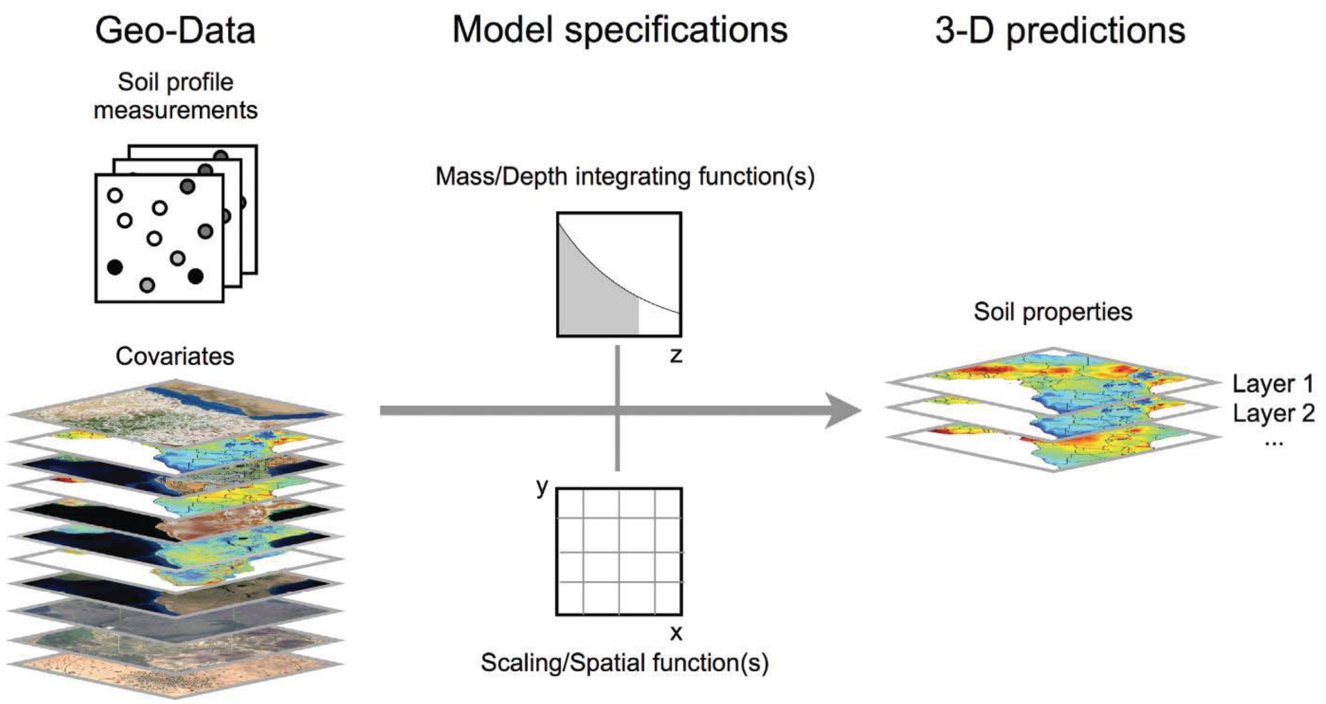
No.	Target Method (Y)	Source Method (X)	Equation	R2	Reference
1	pH (1:1 0.01 m CaCl2)	pH (1:1 water)	y = 1.08(x) - 0.973	0.98	Miller and Kissel (2010)
2	pH (1:1 0.01 m CaCl2)	pH (saturated paste)	y = 1.10 (x) - 0.923	0.98	Miller and Kissel (2010)
3	pH (1:1 0.01 m CaCl2)	pH (1:2 water)	y = 1.05 (x) - 0.950	0.97	Miller and Kissel (2010)
4	pH (1:1 water)	pH (1:1 0.01 m CaCl2)	$y = x + 0.267 (EC\ 1{:}1\ water)^{-0.445}$	0.99	Miller and Kissel (2010)
5	pH (1:2 water)	pH (1:1 0.01 m CaCl2)	$y = x + 0.239 (EC\ 1{:}1\ water)^{-0.505}$	0.98	Miller and Kissel (2010)
6	pH (1:5 0.01 m CaCl2)	pH (1:5 water)	y = 1.012 (x) - 0.76	0.99	Conyers and Davey (1988)
7	pH (1:5 0.01 m CaCl2)	pH (1:5 water)	y = 0.979 (x) - 0.71	0.68	Bruce et al., (1989)
8	pH (1:5 0.01 m CaCl2)	pH (1:5 water)	y = 0.887 (x) - 0.199	0.88	Aitken and Moody (1991)
9	pH (1:5 0.01 m CaCl2)	pH (1:5 water)	$y = 0.197 (x)^2 - 1.21 (x) + 5.78$	0.92	Aitken and Moody (1991)
10	pH (1:5 0.002 m CaCl2)	pH (1:5 water)	y = 0.948 (x) - 0.308	0.90	Aitken and Moody (1991)
11	pH (1:5 0.002 m CaCl2)	pH (1:5 water)	$y = 0.178 (x)^2 - 1.043 (x) + 5.10$	0.94	Aitken and Moody (1991)
12	pH (1:5 1 m KCl)	pH (1:5 water)	y = 0.803 (x) + 0.077	0.81	Aitken and Moody (1991)
13	pH (1:5 1 m KCl)	pH (1:5 water)	$y = 0.233 (x)^2 - 1.797 (x) + 7.143$	0.98	Aitken and Moody (1991)
14	pH (soil solution)	pH (1:5 water)	y = 1.28 (x) - 0.613	0.78	Aitken and Moody (1991)
15	pH (soil solution)	pH (1:5 0.01 m CaCl2)	y = 1.105 (x) - 0.140	0.79	Aitken and Moody (1991)
16	pH (soil solution)	pH (1:5 0.002 m CaCl2)	y = 1.050 (x) - 0.112	[illegible]	[illegible]
18	pH (soil solution)	pH (1:5 1 m KCl)	y = 1.175 (x) - 0.262	0.80	Aitken and Moody (1991)

Source: GlobalSoilMap (2013)

WoSIS web service for easy access



From points to grids



SoilGrids

- **Automated** soil information system
- Using **profile** data and **spatial** information (covariates)
- **Machine learning** algorithms
- 250m * 250m **resolution**
- Accessible through **web service** and mobile phone **app**

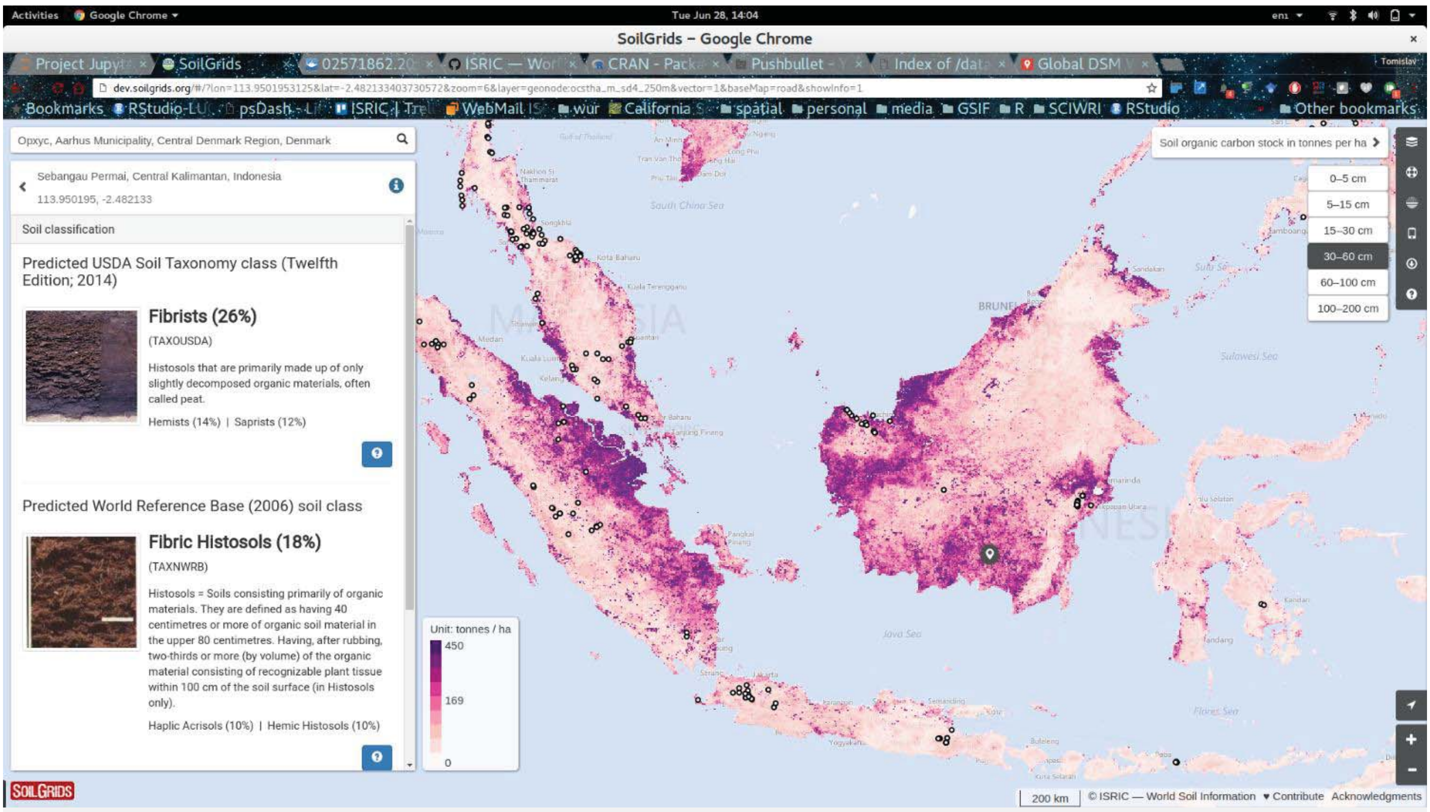
- Updatable
- Open data
- Moving towards crowdsourcing

SoilGrids
A system for automated global soil mapping
www.soilgrids.org

SoilGrids: clay content at -15 cm (%)

ISRIC World Soil Information

SoilGrids: SOC stock 30-50 cm (ton/ha)



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Relevant Developments

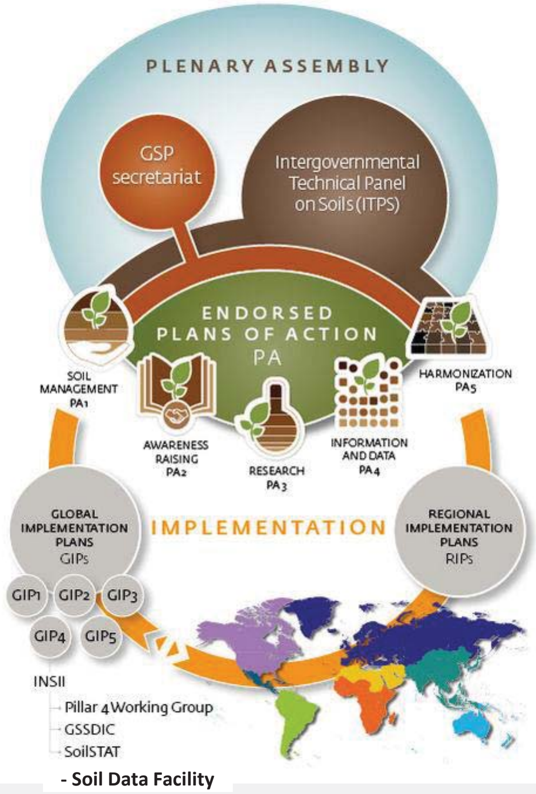
Preferred supplier to UNCCD

Land Degradation Neutrality

- **SDG 15.3**
- **Three sub-indicators**
  - Land use change
  - Net Primary Production
  - Soil Organic Carbon (SOC)
- ISRIC provides baseline SOC data to all countries
- Challenge: monitoring

United Nations Convention to Combat Desertification

The Global Soil Partnership



- Partners: governments, knowledge institutions, NGOs
- Goal: enhance sustainable soil management
- Pillars 1-5 (thematic)
- Regional partnerships
- ITPS (technical back-up)

Pillars of Action

- **Pillar 1: Soil Management**
  - Promote sustainable management of soil resources
- **Pillar 2: Awareness Raising**
  - Encourage investment, technical cooperation, policy, education, awareness and extension in soil
- **Pillar 3: Research**
  - Promote targeted soil research and development focusing on identified gaps, priorities and synergies
- **Pillar 4: Information and data**
  - Enhance the quantity and quality of soil data and information
- **Pillar 5: Harmonisation**
  - Harmonisation of methods, measurements and indicator for the sustainable management of soil

Work stream 4:
Developing derived Products
('Boosting Impact')

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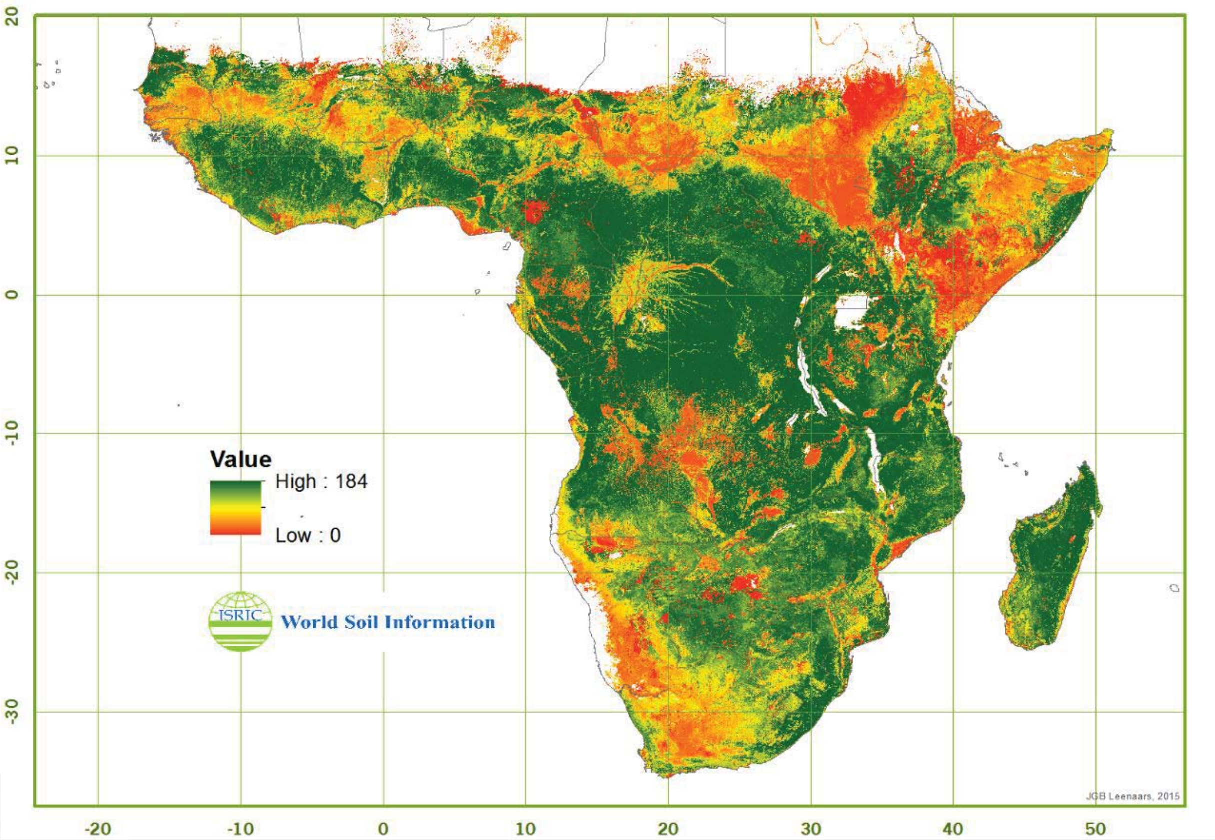
Plant-available water holding capacity (mm, maize)



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Information platform for production of site specific fertilisers

ISRIC World Soil Information

Concluding remarks

- Soil information and its derived products are **crucial for addressing global challenges**
- Standardisation and harmonisation of field and lab methods are of crucial importance for the **quality of global soil information products and the derived products**
- With partners we are working towards **global soil data inter-operability**
- The quality-assessed data will be served using an increasing range of **web-services through ISRIC's evolving SDI**
- **ISRIC supports SOPHIE** and its results can easily be accommodated in the WoSIS database structure.

ISRIC World Soil Information

More information:
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www.isric.org

SOPHIE: Common desires & actions

Martine van der Ploeg, board member International Soil Modeling Consortium

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ISMC

International Soil
Modeling Consortium

What is ISMC?

ISMC

A recently formed and growing international group of soil process modelers is focused on improving the soil process description and overall parameterization of earth system models:

Global- and regional-scale climate models

Ecological models that include ecosystem services, soil carbon, etc.

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Current Status of Soil Model Development

Modeling soil processes is fragmented and dispersed, lacking exchange between different soil disciplines and across other disciplines

An improved visibility of soil research and modeling in the Earth Sciences Community is needed.

The scientific community lacks easy-to-access and available standardized and high quality data and protocols for calibrating and validating soil models

A better exchange of ideas, expertise and need for development of joint activities through cross-cutting topical areas

The International Soil Modeling Consortium (ISMC) aims to address these issues

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Challenge: A Need to Focus...

Substantial
Soil influence

Possible Stakeholders

Earth Science Disciplines

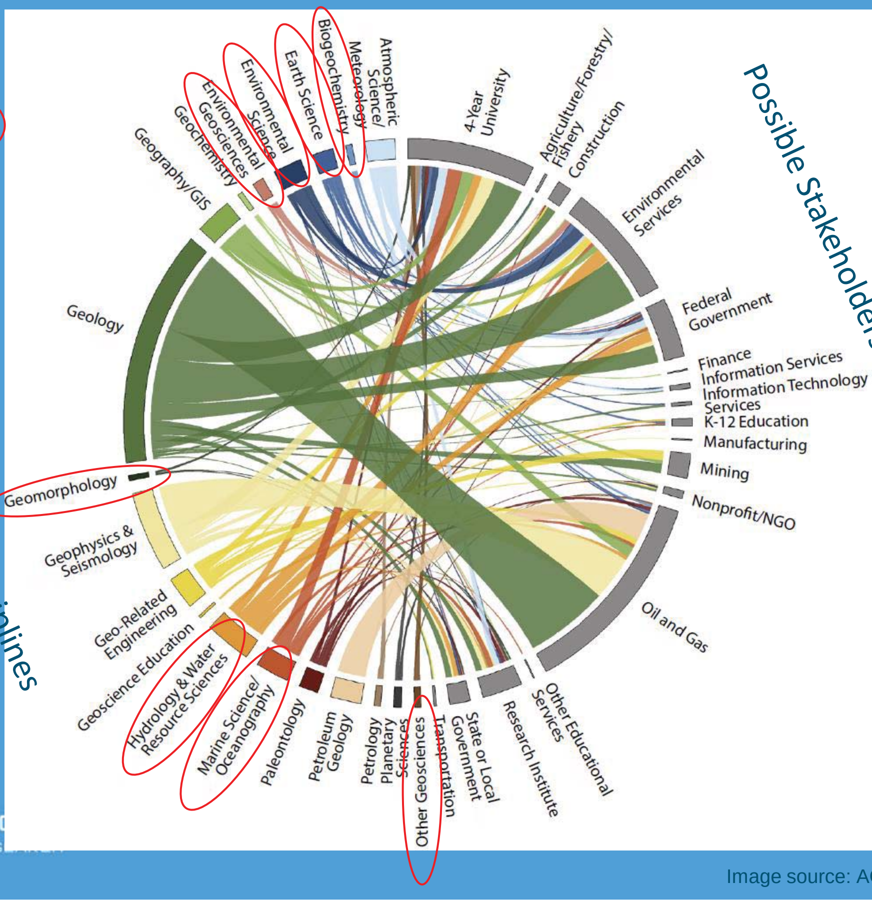

Image source: AGI, 2017

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Better Soil Models: A Way to Integrate…

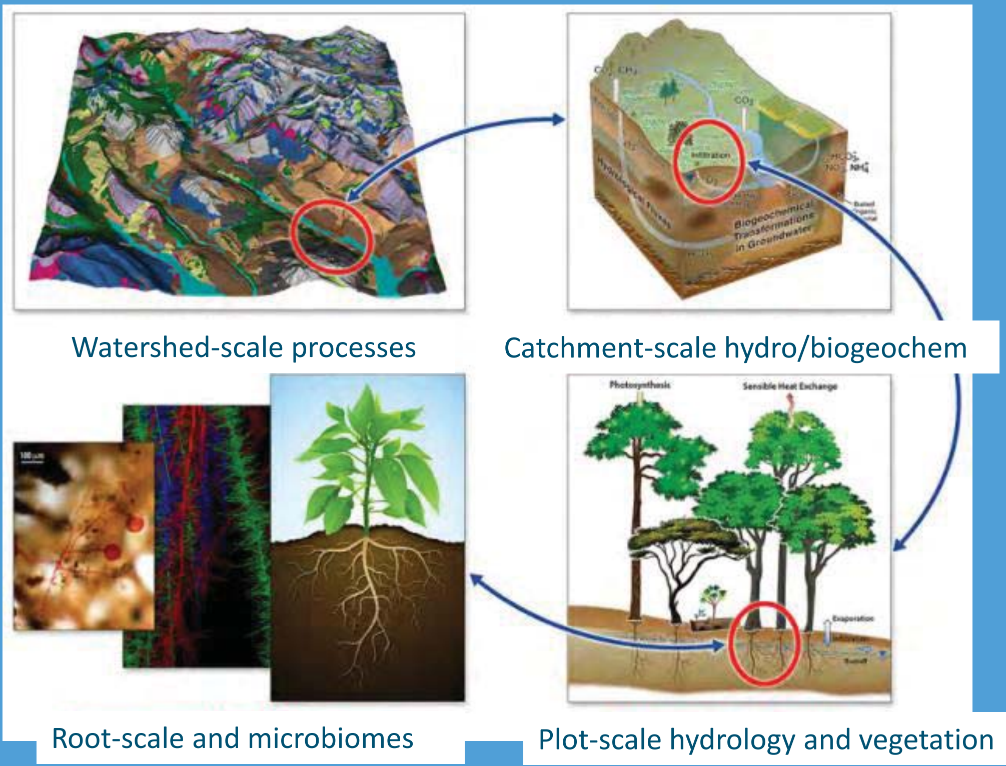

Image source: USDOE 2015

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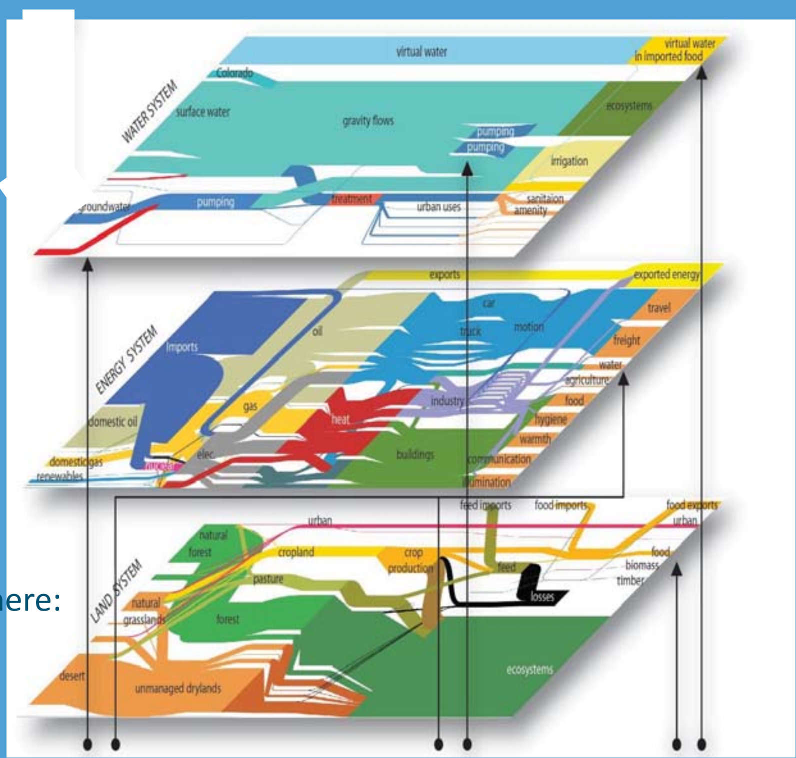
…Soil Processes into Integrated Assessments



Soil goes here:

Source: Forseer tool, Julian Allwood, Univ of Cambridge, 2012, http://forseer.org

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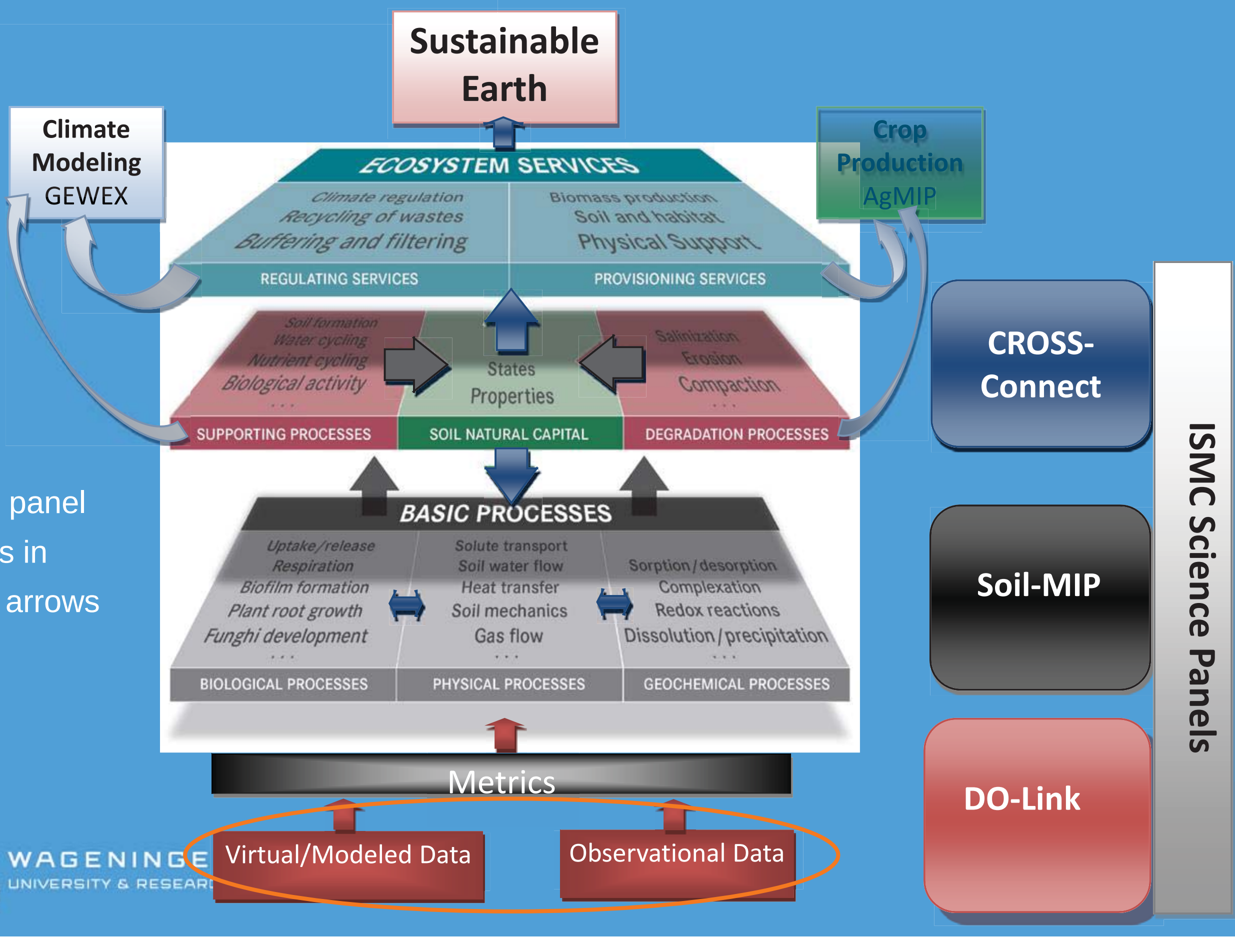
ISMC Schematic*

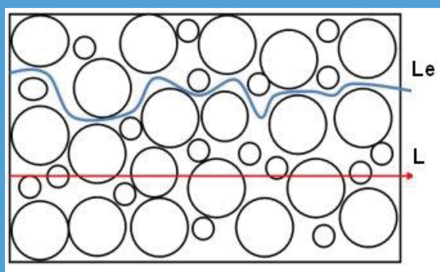


* Science panel activities in colored arrows

Soil process questions

Soil grain scale

- How does microbial diversity depend on variability in soil composition?
- To what extent does small scale heterogeneity matter at larger scales, for example for soil carbon or nutrients?



Top: Schematic soil structure. Bottom: Iron oxidizing Leptothrix bacteria (Credit: Bertram Schmidt, CC, distributed via imaggeo.egu.eu).

Soil process questions

Profile scale

- How much does local variability in the soil impact carbon and nutrient cycling in soils?

Top: Cracks in clay soil (Credit: with kind permission from Bram te Brake). Bottom: Preferential flow patterns through soil (Credit: with kind permission from Esther Bloem)

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Soil process questions

Local/Farm scale

- How do small scale interventions on the landscape alter hydrological flow paths and sediment transport?

Top: Farm fields in Exmoore, UK (Credit: María Burguet, CC, distributed via imaggeo.egu.eu). Bottom: Pivot irrigation (Credit: Photo by John A. Kelley, USDA Natural Resources Conservation Service via Flickr under Creative Commons licence).

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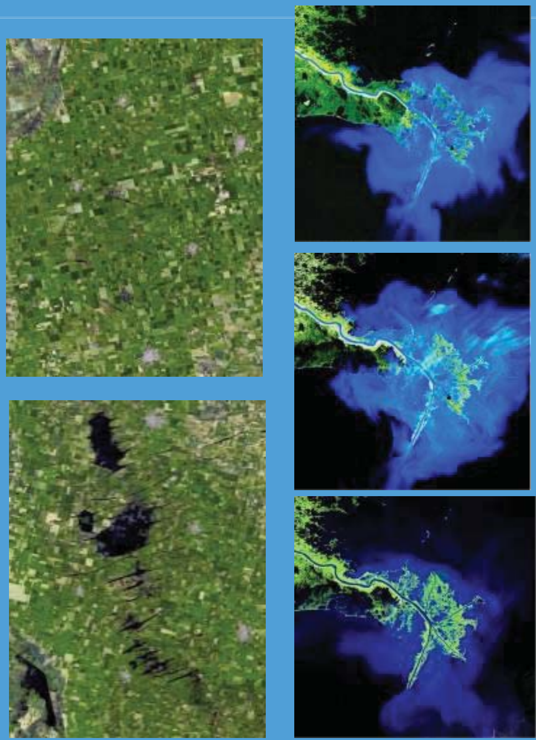
Soil process questions

Basin scale

- How are hydrological, sediment and habitat function altered by major infrastructure?
- How do vegetation patterns combined at river basin scale influence water and sediment transport?



Left: Landsat 8 imagery before (top) and after (bottom) flooding in Argentina. Right: Landsat 1, 5, 7 imagery of three decades of change in the birdsfoot delta of the Mississippi River (Data available from the U.S. Geological Survey.)

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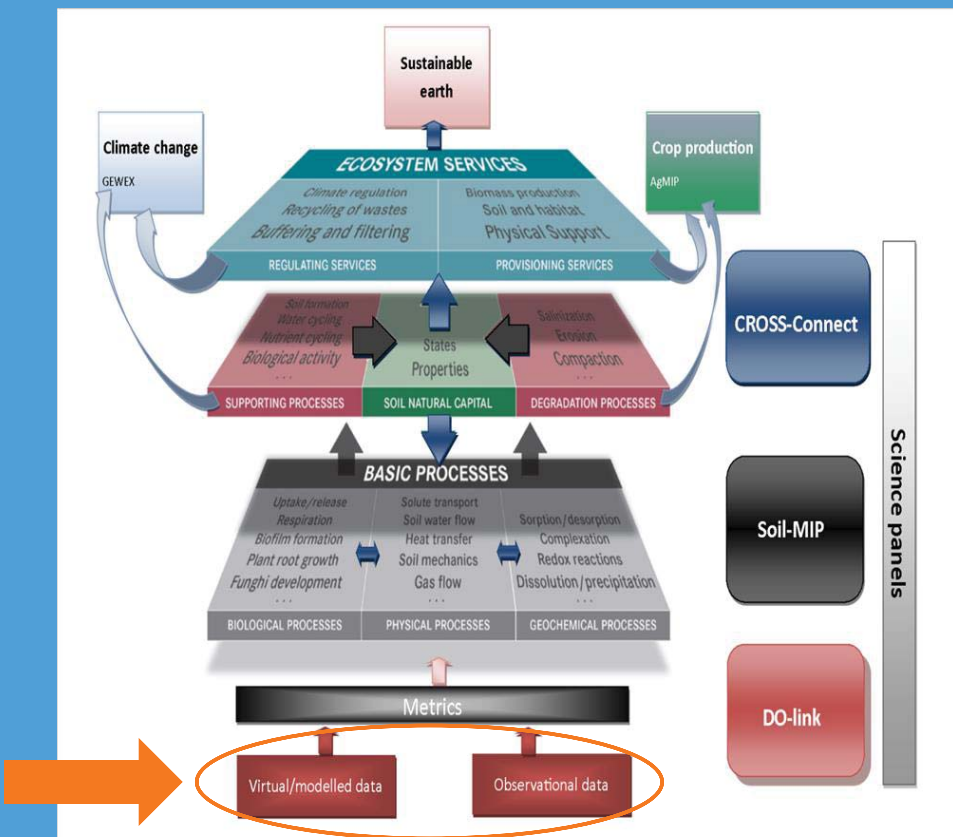
Need for well defined data



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Relevant Data Questions in ISMC and SOPHIE?

- Stakeholders have unique requirements
- Comparison laboratory data/field/regional/global data?
- Innovation in different sensors (remote sensing, big data)
- Are different sensors comparable (harmonisation)
- Which data sets can be used to calibrate models?
- Different labs, same results?

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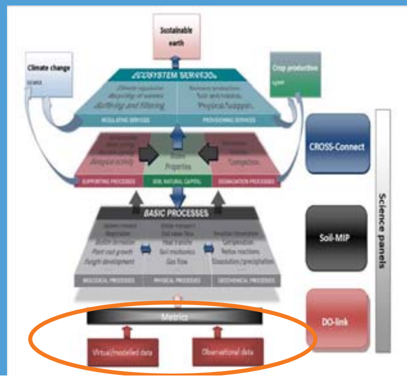
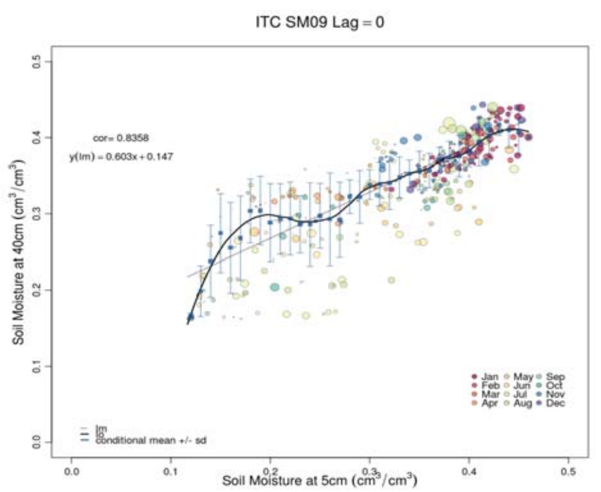
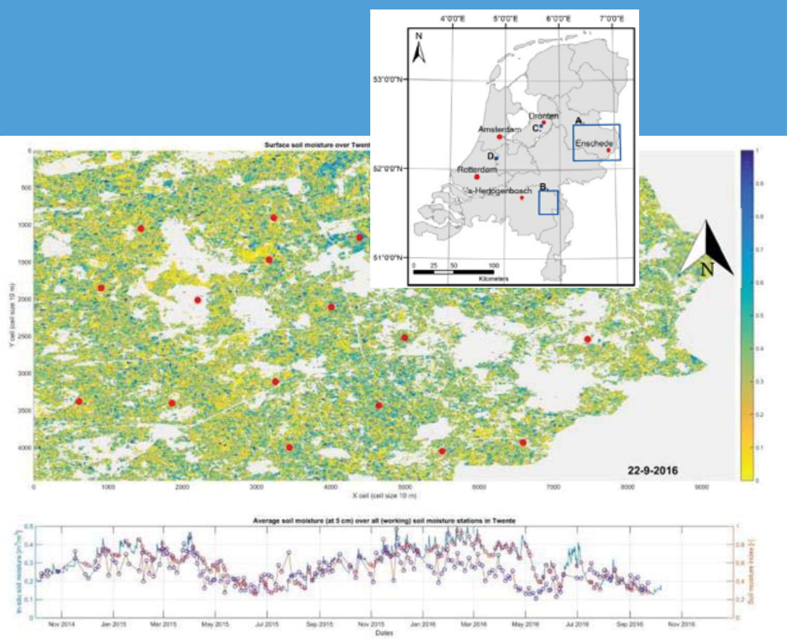


Emergent properties: Big data observations

- For example, soil moisture product from Sentinel-1
- For dynamic water management insight in subsurface response is needed.





Common Action

- Cost Action Application Global Soil Footprint
- Derived from the idea that (costs for) global exports depend on local soils. Soil threats are expressions of the global demand for resources.
- Connects part of ISMC & SOPHIE data questions
- ISMC modelling efforts with various stakeholders

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ZERO NET LAND DEGRADATION

Thank you for your interest

martine.vanderploeg@wur.nl

Have a look at soil-modeling.org

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ISMC International Soil Modeling Consortium